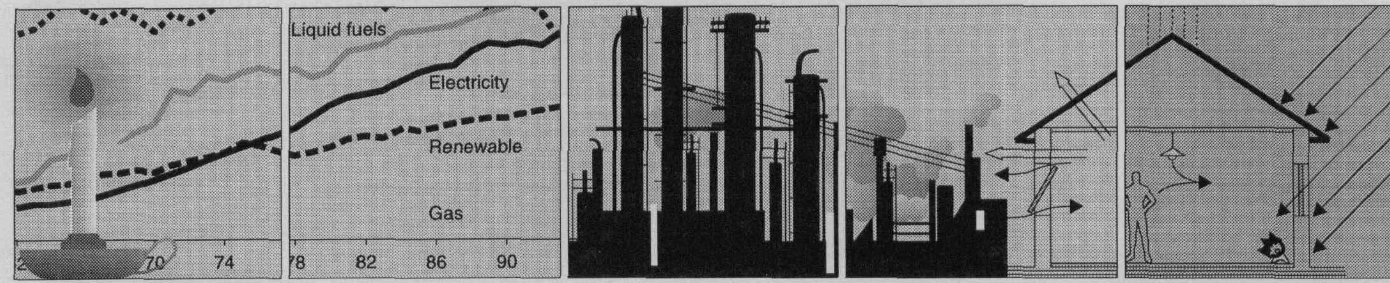
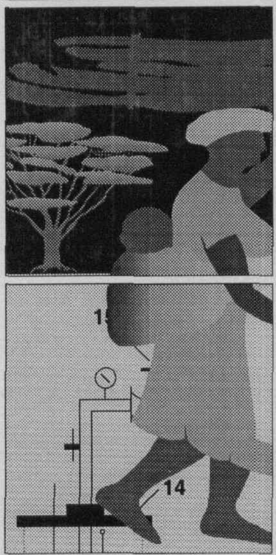
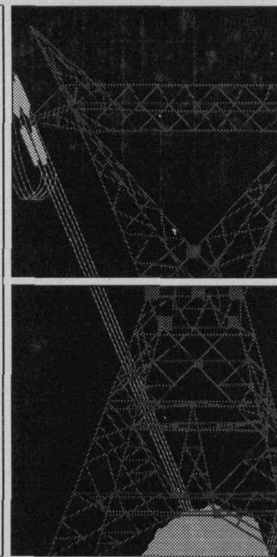
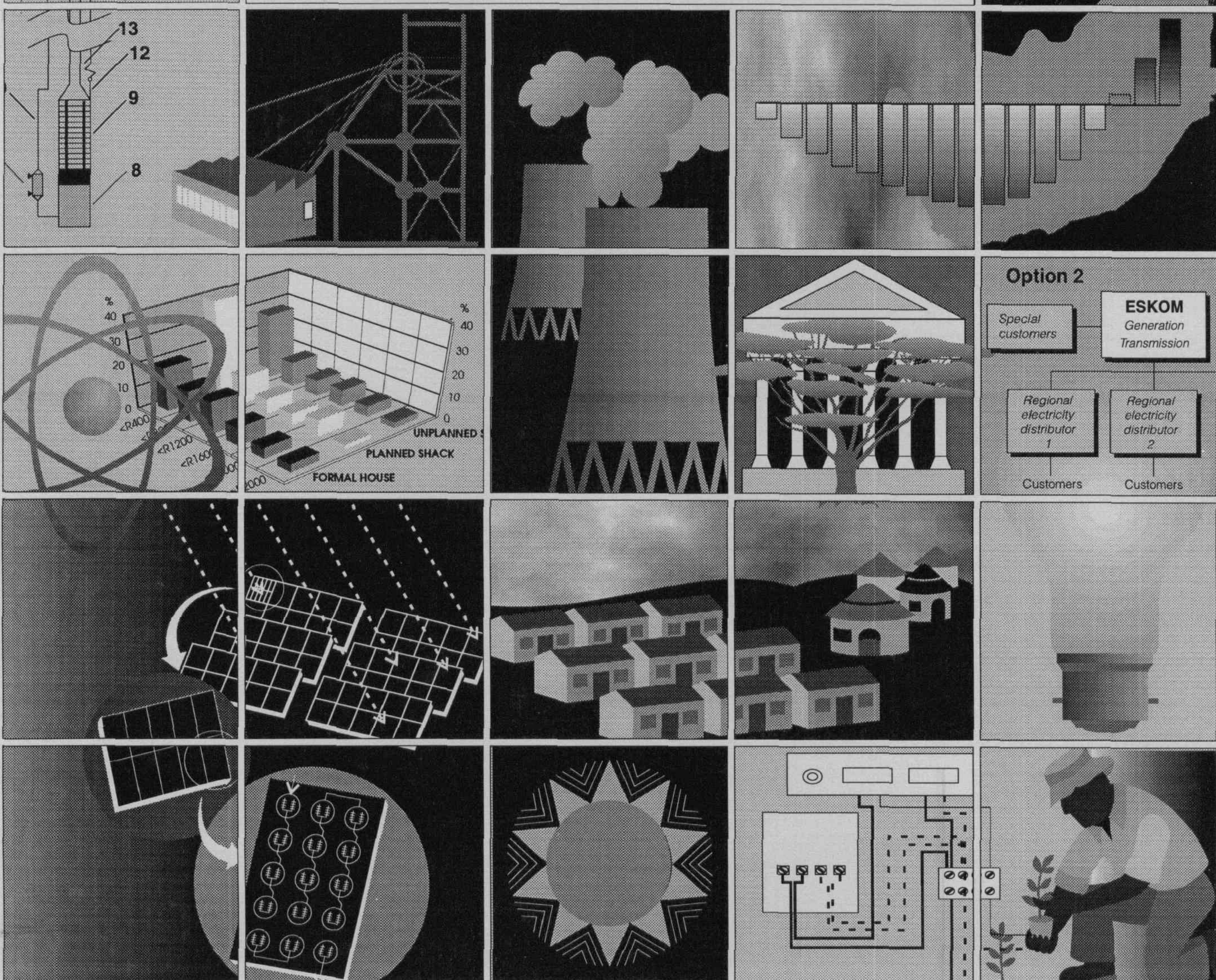


# Energy efficiency potential in the South African economy: A review

STEVE THORNE

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# Energy efficient potential in the South African econony: a review

Steve Thorne

This report was prepared as part of the project entitled: "Energy efficiency, equity and the environment : improving the access to energy services for the urban poor of South Africa". The project is funded by the International Development Research Centre and Eskom whose support is gratefully acknowledged.



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# 1. Introduction to the SA energy economy and the role of energy efficiency in its development

South Africa, with less than one per cent of the world's population, utilises 1.6 to 2 per cent of the world's total energy. Three-quarters of this is derived from coal. With the low cost of coal mining, South African energy is cheap by international standards, and provides industry, commerce and mining with a competitive advantage in international markets. However, many energy specialists contend that this competitive advantage is often squandered as a result of inefficient energy transformations. As a result the economy is energy intensive, and is characterised by inefficient energy utilisation and high levels of pollution in urban and industrial areas. While electricity is cheap for industrial, commercial and other sectors, it is either not available or a relatively costly item in the household budgets of the urban and rural poor. It is the aim of the new government, however, to improve access to adequate and affordable energy services for these people. Energy efficiency could have a significant contribution to make in this effort.

The new South African Government of National Unity has initiated the Reconstruction and Development Programme (RDP) with parallel goals of building the economy and meeting basic needs. In meeting basic needs, the government has stipulated goals to be achieved within a five year time frame - goals which include the building of one million housing units and the electrification of 2.5 million households. While the delivery of basic needs in a programme of this magnitude is locally unprecedented, the incorporation of energy efficiency, and the concurrent improvements in energy service affordability for low-income households, would constitute an international precedent. Improving the thermal performance of dwellings and the energy efficiency of households' energy services at the time of access could result in the saving of natural resources and reduced pressure on the limited incomes of the poor. In this regard the crucial question that has to be posed in the current socio-economic climate of improving equity in a resource-limited environment is whether investments in the steel and concrete of power stations are not better made in the homes of the poor in their management of demand for electricity.

The promotion of household energy efficiency measures can contribute to the improving of the quality of life of the poor. By reducing energy use, concurrent reductions in the micro-environmental problems associated with solid and liquid fuel, decreases in energy related expenditures, and contributions to horizontal (access) and vertical (affordability) equity in energy service provision in South Africa can be expected. Therefore, gains in energy efficiency could be encouraged because they are likely to lead to the conservation of non-renewable resources, amelioration of micro- and macro-environmental damage, and an increase in micro- and macro-economic benefits.

It may be considered inappropriate to focus on the "luxury" of energy efficiency when so many South Africans experience conditions of energy poverty and when the economy needs to develop, but these are precisely the conditions under which energy efficiency could flourish if linked to what both end-users and society or the national economy as a whole can afford. Energy efficiency will facilitate the spreading of limited financial resources, allowing them to go further in meeting essential needs other than energy. It is the poor, especially poor women, more than any other population sector, who already practice energy efficiency and conservation measures in managing their deprivation. This makes them potential candidates or partners to participate in energy efficiency and conservation programmes, particularly if these are initiated at the time of access to electricity and housing.

This paper presents a first-pass estimate of the potential energy savings and benefits of energy efficiency strategies. It compares the costs and/or benefits and the extent of the energy savings in transport, industrial, commercial, and various domestic sectors. It is important to note that interventions in the target sector (the urban poor) may deliver benefits which are substantial not only in household but in national economic and political terms. Such benefits as health improvements or reducing social costs (such as improving equity in access to energy services), the amelioration of environmental degradation and employment creation opportunities are not costed in this study.

The cash costs presented here are those which are considered for the differences in life-cycle costs (not including external costs) between different strategies, that is between a baseline (conventional approach and a more efficient alternative). Such comparisons could likewise apply to alternative technologies or practices.

### 1.1 Methodology for assessing the costs and benefits of energy efficiency in the different sectors

The relative costs and benefits of the different energy efficiency options were estimated using the methodologies proposed by Sathaye and Gadgil (1992), Gadgil and Januzzi (1990), Gadgil and Rosenfeld (1990), and Vine and Harris (1989). These methodologies are used to calculate the costs of conserved energy (CCE) and the costs of avoided peak installed electrical generating capacity (CAPIC).

### 1.2 Sources of data

The information used to describe the *domestic* savings were drawn from previous studies including Lane (1995), Thorne (1995), and Rosseau (1995). Central to the information relating to *commercial* and *industrial* interventions is the research of De Villiers (1995), De Villiers and Dutkiewicz (1994) and Mohammed (1995). Time-of-use tariffs and some commercial data were sourced from Eskom load research and the proceedings of the Enerconomy conferences (1992 and 1993). Strategies for improvements in energy efficiency of road *transport* were assembled by the Council for Scientific and Industrial Research (CSIR)(Dehlen 1986).

### 1.3 Contents of the other parts of the paper

Part 2 considers the energy use and potential for savings in the different energy sectors in South Africa. Part 3 proceeds to describe some of the strategies which would deliver energy efficiency improvements in each of these sectors. This part also provides a first pass cost estimate of the different interventions. Finally, Part 4 offers conclusions, making reference to the low-income urban household sector relative to others, and to the role of international protocols and local strategies in addressing the energy interests of this sector.

## 2. Energy use and potential for efficiency sector by sector in South Africa

In South Africa, the main net users of energy are industry (39%) transport (25%) and households (20%). Between 1970 and 1989 domestic energy use has been growing at a annual rate of 1.5%, agricultural use at 2.1%, mining at 3%, industrial/commercial use 4% and transport 1.2%. Over this period the economy grew at the rate of 1.5% (van Deventer et al 1993). The South African energy economy consumed 15% of the GDP (only Turkey at 16% exceeds this amount). To date the few initiatives that have been initiated have succeeded in reducing this high level of energy use.

It is apparent that the different fuels have different transformation efficiencies for the various services. A choice of fuels for specific energy services is clearly a crucial starting point if energy efficiency is to be achieved. Figure 1 describes the transformation from primary to useful energy of some fuels for a range of applications. A more comprehensive list of fuels, energy services and the transformations involved appears in Appendix A.

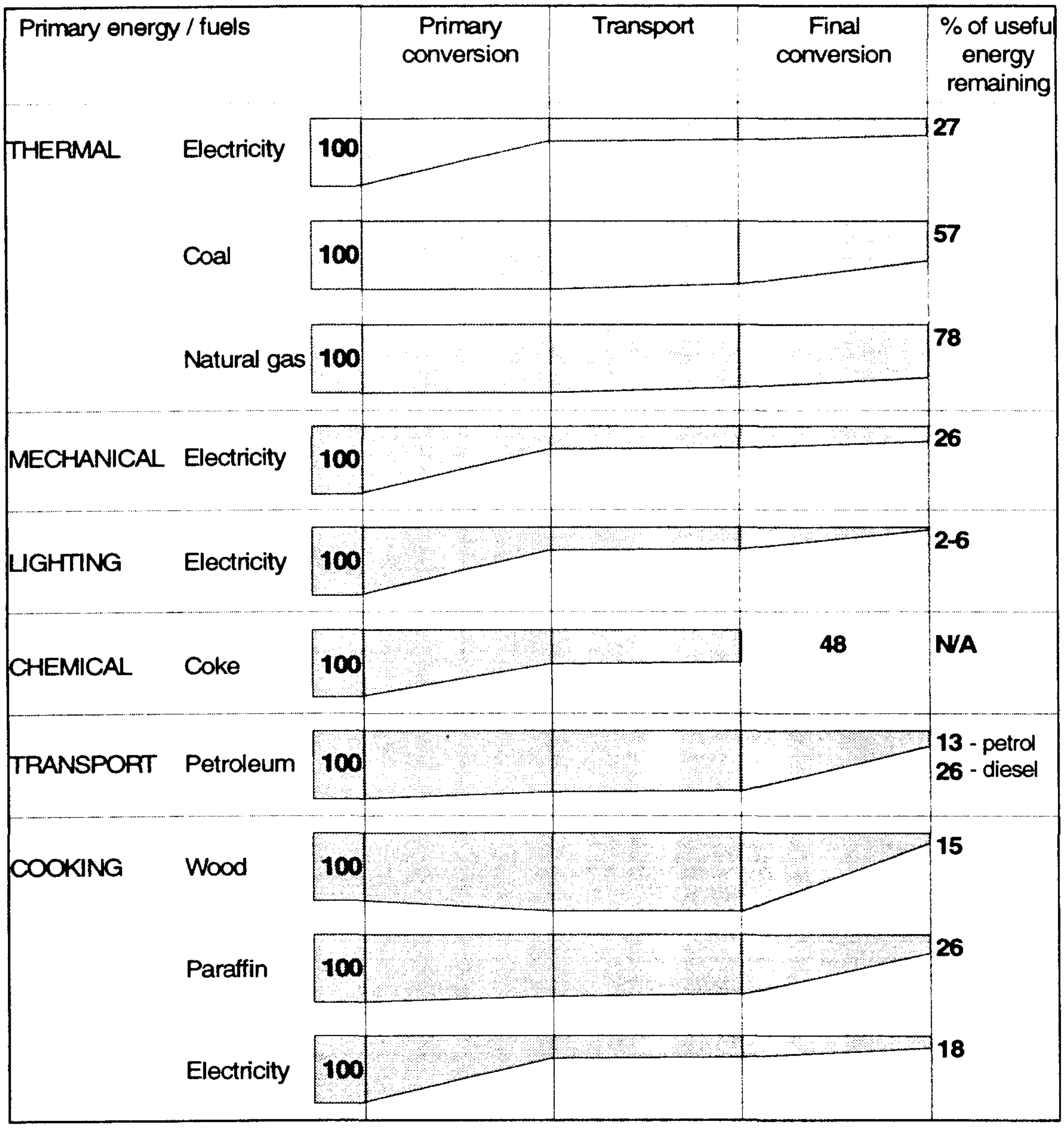


**FIGURE 1** Energy transformations from primary to useful energy
*Source: Neethling and Dutkiewicz (1993) and Leach and Gowen (1987)*

## 2.1 Transport

South Africa uses about 34% of its total commercial energy consumption on transport (Boerne & Hatfield 1994).[1] South Africa is not alone in having high transport-related energy consumption. In 1986, `developing' countries used 22% of their final energy consumption on transport (Levine & Meyers 1991). It has been estimated that about 4% of `developing' countries' GDP is annually invested in the commercial energy sector (an amount of $130 billion annually), and of this amount, an average of 46% goes into electricity, 47% into oil and gas and 7% into coal (World Bank in Rogers 1991).

The potential for improvements in the efficiency of modes of transportation is large. Transport is a broad area in which to consider energy efficiency options. While being an energy service beyond the household, it is intimately connected to land use - or urban form. From an energy efficiency perspective, this implies an examination of land use, the siting of dwellings with

[1] Here energy in transport refers to commercial energy for propulsion and energy embodied in infrastructure.

respect to the proximity of job opportunities, goods and services prior to the consideration of the dwelling structure thermal performance or household energy efficiency. It is also important to note that population density will affect the viability of public transport options and therefore improvements in energy efficiency.

Boerne and Hatfield (1994) have described some of the options facing South Africa. They draw attention to the congestion and environmental problems common to industrialised Northern countries, associated with the widespread use of private automobiles. In South Africa approximately 80% of commuter trips by black people are made on public transport, while 60% of white commuter trips are made by private car (World Bank 1991). Not only are public transport options inadequate they are also expensive. A recent study of Khayelitsha showed that a sample of the community that had access to electricity used about the same amount of household income on energy services (including hire purchase of appliances) as on transport, together consuming nearly 30% of household income (Thorne & Theron 1993).

While transport consumes a large proportion of household income, the cost to the South African economy has also been high. Prior to the secrecy prescribed by the Petroleum Act of 1977, the figure for the monetary value of oil imports was 15% of total imports, up from the 4.6% of 1973 (Boerne & Hatfield 1994).

World consumption of petroleum fuels is increasing, particularly in `developing' countries where the increase is rapid (Sathaye & Meyers 1991). Already 85% of all South African transport is by road (Boerne & Hatfield 1994). The debate around access and mobility will no doubt rage until there is policy in the form of carbon taxes, and levies reduce private vehicle use.

It is estimated that, in 1990, of the 675 Petajoules of crude oil imported into South Africa, transport consumed 343 Petajoules (Trollip 1994). Fuels included petroleum, diesel, coal and aviation fuels. Dehlen (1986) suggests that through a range energy efficiency measures could save 28% of the crude imported for petroleum and 37% of that for the diesel.

| *Types of conservation measures* | *Potential* savings petrol (%)* | *Potential* savings diesel (%)* | *Characteristics of measures* |
|---|---|---|---|
| Transport demand reduction | 8 | 11 | low cost, mainly long term, some popular and some unpopular with public, reduce accidents |
| Transport management | 4 | 6 | some have high capital and subsidy costs, medium term, some unpopular with operators and passengers |
| Traffic management | 3 | 1 | medium implementation cost, reduce operating costs, medium term, labour intensive, some unpopular with motorists, reduce accidents |
| Road and street planning | 3 | 5 | medium to high implementation cost, reduce operating cost, long term, popular with all, reduce accidents. |
| Vehicle efficiency improvements | 9 | 12 | low to medium cost, medium term, some owner resistance |
| Driver training | 5 | 9 | low cost, short to medium term, labour intensive, public disinterested |
| Total | 28 | 37 | |

* percentage of the total South African consumption of petrol or automotive diesel for road transport respectively.

**TABLE 1** Transport energy saving programmes
*Source: Dehlen (1986)*

## 2.2 Commercial sector

The commercial sector is defined as all that is neither transport, domestic nor industrial; this leaves schools, hospitals, shopping malls, retail outlets, universities and so on. Most of the

South African literature revolves around the building shell, air conditioning (both heating and cooling), lighting, computing, and other office and retail equipment requiring energy. All of these services have scope for improvements in energy efficiency.

The possibilities for saving significant amounts of energy in commercial buildings have been demonstrated and documented by Clemitson et al (1993) in the Standard Bank Building in Johannesburg where electricity savings of 36% (or an annual R2.1 million) at Number 5 Simmonds Street, and savings in the order of 50% (with a five-year payback for retrofitting) at the 78 Fox Street bank offices were achieved.

Spoormaker (1993) suggests a potential 50% saving could be achieved by using a building brief that provides guideline for energy consumption. He goes further, providing energy consumption guidelines for different commercial facilities - these are contained in the table below.

| *Function* | *Energy consumption range kWh/m$^2$/annum* |
|---|---|
| Offices >2 000 m$^2$ | 250 - 410 |
| Offices <2 000 m$^2$ | 220 - 310 |
| Hotels | 290 - 420 |
| Cinemas | 650 - 780 |
| Schools | 180 - 240 |
| Supermarket | 1 070 - 1 350 |
| Universities | 325 - 355 |
| Mini-factories | 190 - 270 |

**TABLE 2** Energy performance yardsticks
*Source: Spoormaker (1993)*

The total amounts of rentable commercial space (in millions of square metres) in the major urban centres in South Africa, are roughly: 4.7 in and around Johannesburg; 1.5 each in Cape Town and Pretoria; and 0.9 in Durban (SAPOA 1995). For the remaining commercial spaces there appear to be no aggregated statistics.

Rosseau (1995) cites Anderssen in suggestion that 70% of the energy used in this sector is for air-conditioning and lighting and that there are significant energy efficiency gains to be made in both. Much of the gains could be made through passive lighting, heating and cooling, and in the technologies that transform the energy into the desired services.

Piani and Mathews (1995) conclude that in Gauteng and Cape Town savings achieved from energy efficiency in lighting and air-conditioning could be estimated at 13% and 25% respectively. There are no indications of the level of savings for hotels or shopping malls and other constituents of the commercial sector.

### 2.3 Low-income residential sector

There were 7.5 million households in South Africa in 1990. Of these, 20% were urban informal and roughly 40% each were urban formal and rural households. Trollip and Williams (1993) estimate that in the 20 years from 1990 to 2010 there will be a 30% increase in housing, predominantly in the urban informal sector. Trollip (1994) estimates that in 1990, amongst the urban and rural low-income sector, 54% of the energy consumed was from wood, 29% was coal, 10.5% paraffin, and the rest electricity (3.7%) and LPG (3%).

In the low-income residential sector little energy is used, but meeting energy needs has severe effects on the household and often the micro-environment and the health of the sector. However, the cost of energy services results in careful consideration being given to the choices of fuels and appliances in order to maximise utility within the constraints that a low-income dictates.

There are many opportunities for the improvement of energy efficiency in this sector, particularly in the provision of the heavy thermal loads required for cooking, water and space heating. Some of these options are addressed through the residential demand-side management (DSM) strategy summarised below.

These five programmes of the DSM strategy are similar to those proposed by the Eskom small customer demand-side management ten-year plan (Ligoff 1993) and could constitute the core of a national energy efficiency strategy. Despite low access to electricity, many of these programmes could be applied to households without access to electricity, or applied at the time of access to electricity.

The programmes included in the energy efficiency strategy are:

- improved thermal performance of housing;
- introduction of solar water heating reducing the use of electric hot-water storage geysers;
- compact fluorescent lighting replacing incandescent light for high-use lighting;
- appliance energy performance appearing on labels in retail outlets;
- domestic time-of-use electricity tariffs.

The measures discussed here are those which are realisable for two main reasons:

- the residents of these homes are currently gaining access to housing and electricity; and
- with assistance in the form of affordable credit and access to information, these households are likely to make informed decisions with respect to the life-cycle cost of their energy services (Thorne 1995).

## 2.4 Medium-to-high-income residential sector

In the medium-to-high-income residential sector the costs of energy services are low relative to household income. Accordingly, unless household decision making is affected by issues other than reliabilty, convenience and appearance, this sector's movement towards improvements in energy efficiency is unlikely on the basis of energy cost reduction. The penetration of energy efficiency techniques and technologies is likely to be low unless incentives for energy efficiency improvements are provided and/or regulations are applied to building codes or appliance performance. In the event that such policies were promulgated, levels of penetration similar to those of low-income houses could be expected in the medium-to-long term, as houses are built or as existing appliances fail and are replaced.

There are also energy services which are peculiar to this sector, for example swimming pool pumps and air-conditioners, which could be timed not to coincide with peak demand.

A recent study by Lane (1995) of some 39 medium-to-high-income households in Pretoria reveals that the average consumption of electricity in these households is 1 800 kWh and 1 140 kWh in winter and summer respectively. The main consumers of electricity were water heating (32%) and space heating (27%) in winter, and water heating (29%) and refrigeration (28%) in summer. The main contributors to peak electricity demand were water heating (32%), space heating (27%) and lighting (14%). Considering that there are estimated to be between two and three million medium-to-high-income households in South Africa, the potential savings from this sector are significant if energy efficiency technology and technique penetration is anything like that expected in the low-income sector. But the potential for improving the thermal performance of existing houses is, however, low, as is the replacement of fixed energy consuming appliances, like water heaters. Rapid changes are more likely to occur in the replacement of incandescent by fluorescent lights.

## 2.5 Industrial sector

Energy efficiency opportunities can be broadly divided into existing retrofit opportunities and future opportunities for new systems. Future opportunities depend to a large extent on the growth of industry. Only existing opportunities will be examined in this analysis. Industry uses about 950 PetaJoules/annum of energy, of which nearly 30% (95 000 Gigawatthours/annum) is electricity. Efficiency improvements in this sector include more efficient motors, coolers and heaters, and variable drive motors.

Of the 31 industrial groups the five major groups use in excess of 70% of the total primary energy. These are listed below in Table 3.

| *Industrial group* | *Net energy consumption (PJ) in 1991* |
|---|---|
| Gold mining (gold and uranium) | 87 |
| Food | 90 |
| Paper and paper products | 66 |
| Other non-metallic minerals | 82 |
| Base metals (both ferrous and non-ferrous) | 314 |
| Total | 640 |

**TABLE 3** Net energy consumption of biggest industrial consumers of energy
*Source: De Villiers and Dutkiewicz (1994)*

### 2.5.1 *Motors*

From a comparison between the efficiencies of locally produced motors and energy efficient motors from other countries it would appear that locally produced motors have reasonably good efficiencies. More efficient motors can be imported but the prices of such motors are not locally available. A rough estimate from General Electric Company is that imported medium-sized motors could be made 0.5 - 1% more efficient with a 20% increase in production costs. However, they do not believe that there would be a sufficient market to justify local production. The following table shows estimates of the cost-benefits of using higher efficiency motors. The payback time is calculated assuming 4 000 hours/year full load usage and an electricity price of 16c/kWh. Efficiencies are at full load and 2 800 rpm. For the sake of the calculation, the incremental cost for all motor sizes is assumed to be 30% above the standard cost.

| *Power (kW)* | *Standard payback efficiency (%)* | *Improved efficiency (%)* | *Incremental costs (Rands)* | *Incremental savings (kWh/year)* | *Payback time (years)* |
|---|---|---|---|---|---|
| 5.5 | 82 | 84 | 450 | 640 | 4.4 |
| 22 | 90.8 | 92 | 1 800 | 1 300 | 8.7 |
| 75 | 93 | 93.9 | 6 300 | 3 992 | 12.7 |
| 200 | 95.5 | 96.2 | 13 200 | 6 096 | 13.5 |
| 2 000 | 96.5 | 96.9 | 90 000 | 34 221 | 16.4 |

**TABLE 4** Motors and the potential for savings
*Source: De Villiers (1995)*

Electricity consumption by industrial motors is about 56 000 GWh/year (59% of industrial electricity consumption, according to Olivier (1988), who also gives a breakdown of industrial motor electricity consumption and a breakdown of total motor supply (all sectors) in 1987.

| *Motor size* | *Per cent of total motor electricity consumption* | *Number of motors supplied in 1987* |
|---|---|---|
| <22 kW | 23 | 684 000 |
| 22 - 100 kW | 43 | 37 000 |
| >100 kW | 34 | 1 700 |

**TABLE 5** Numbers of motors and their energy consumption
*Source: De Villiers (1995)*

It would appear that greater opportunities for rapid upgrades to more efficient motors exist for the small- and medium-sized, because of the more quicker turn over of these. If 20% of existing electric motors under 100kW were replaced with 1.5% more efficient motors, then the annual saving in electricity would be 554 GWh/year. Penetration of energy-efficient motors into the market in the future would obviously also produce energy savings.

### *2.5.2 Variable speed drives*

Variable speed drives (VSDs) are often assumed to be unprofitable because of their high cost. However, they could potentially save a large amount of electricity. VSDs have not yet penetrated a reasonable share of their potential market. If it is assumed that 10% of motors could be fitted with VSDs producing an average electricity saving of 20%, then electricity savings would be 1 120 GWh/year. The savings of a VSD depends on the application of the motor, that is, the fraction of the time it is not required to run at full load. The payback is calculated assuming 4 000 hours/year operation at 100% loading (before application of VSD) and an electricity price of 16c/kWh.

| *Motor size (kilowatts)* | *VSD Cost (Rands)* | *VSD cost (Rands/kilowatt)* | *Payback period (years)* |
|---|---|---|---|
| 2 | 3 500 | 1 750 | 10.3 |
| 11 | 16 000 | 1 450 | 9.7 |
| 15 | 18 000 | 1 200 | 8.4 |
| 110 | 65 000 | 590 | 4.3 |
| 315 | 140 000 | 440 | 3.3 |
| 600 | 220 000 | 370 | 2.7 |
| 1 200 | 550 000 | 460 | 3.4 |

**TABLE 6** Variable speed drives and their costs
*Source: De Villiers (1995)*

### *2.5.3 Cogeneration*

Cogeneration is the simultaneous generation of heat and electricity. Anderssen (1992) has estimated that there is a national potential for 1 471 MW of additional cogeneration, most of it in a few large chemical and paper and pulp plants. Conventionally, the efficiency of electricity generation is around 34% and the efficiency of the generation of steam prior to driving turbines is around 57%. Cogeneration of electricity and steam can be achieved with an efficiency of 70-90%, saving about 23% of fuel usage. The fuel used for cogeneration can range from a waste product to a high quality fuel such as gas. However, the heat from cogeneration needs to find a market close to where it is generated. It is estimated that the average payback time for the cogeneration opportunities that Anderssen (1992) refers to is four to six years.

### *2.5.4 Housekeeping*

These measures are usually no/low cost and include fixing of leaks, improved maintenance, switching off of equipment when not required, and repairing of damaged insulation. Housekeeping opportunities can usually save up to 10% of an energy bill. In South Africa it is estimated that about 5% of industrial energy consumption could be saved through housekeeping measures (de Villiers 1995). Housekeeping opportunities are often identified through an energy audit, but this does not guarantee implementation. Housekeeping requires a management commitment and accountability.

### *2.5.5 Boilers*

In South Africa coal (costing around R70/ton or 1c/kWh on the Highveld) is by far the most common fuel used in boilers. It is estimated by Botha and Dutkiewicz (1991) that 6 100 boilers exist in the 200 000 to 300 000 kg/hour range (typical industrial-sized). De Villiers (1995) estimates that boiler efficiencies could be improved by 3-5% on average with a payback time of one year or less. He estimates that boilers consume 250 PetaJoules/annum. A boiler test, costing between R1 000 and R2 000, results in an average fuel saving of about 3% (Naude 1993), but these savings are often not sustained. Some countries offer subsidised boiler tests. A more sustainable measure is improved operator training and boiler management. The payback on such a measure is very short but the problem is motivating companies to implement this. Generally, the smaller a company the greater the potential for boiler fuel saving. Installation of an automatic control system is only justified if the boiler is operated competently. Only then will automated boiler controls improve boiler efficiency by about 2% (Merry 1994) with a payback time of around six months.

### *2.5.6 Insulation*

This includes insulation of furnaces, vessels, and pipes and applies to heating and cooling systems. Quite often insulation is missing or insufficient. Thicker insulation is usually justified: the type and thickness of insulation required depends on existing heat losses and the acceptable payback period of the company. For such measures most companies require a payback period of less than a few months, but in certain industries, such as steel, much longer payback periods would be acceptable. Considerable opportunity exists for improved insulation with short payback times. De Villiers (1995) estimates that improved insulation may save 0.5% of industrial fuel consumption.

### *2.5.7 Lighting*

Lighting improvements include:

- retrofit of existing systems including replacing lamps, reducing illumination levels, replacing ballasts, replacing reflectors, and improved control; and
- use of efficient lighting systems for new installations, including all the above measures, as well as daylighting.

Although information is available on the consumption of different light sources in South Africa (Leuschner 1992), no statistics are available for the industrial sector alone. It is estimated by Cooper (1992) that industry uses 4 690 GWh for lighting yearly. Lighting therefore represents 4.9% of industrial electricity consumption and 1.9% of industrial energy consumption. Choice of lighting technology depends on initial cost, energy efficiency, life expectancy, maintenance costs, colour appearance, colour retention, and activities in the area to be illuminated. Florescent lamps are the most common type of industrial lighting. In Brazil it is claimed by Geller (1990) that it costs $0.04/kWh for replacing incandescent lamps with florescent lamps, and $0.025/kWh for replacing self-ballast lamps with high-pressure sodium lamps; both of these are below the Brazilian electricity tariff which was $0.058/kWh in 1990.

De Villiers (1995) maintains that opportunities for more efficient lighting exist in South African industrial sector but he does not estimate the potential size of the market. However, he maintains that the installation of more efficient florescent systems (retrofit and new) is the largest opportunity to improve the efficiency of lighting. De Villiers estimates that improved lighting could save industry 60% of total lighting electricity consumption. It is estimated by Leuschner (1992) that 10.5 million flourescent lamps are consumed in South Africa annually, a large portion of which will be by the industrial and commercial sectors. To assess the cost-benefits of lighting systems, life-cycle costing should be applied and should include cost of fitting, replacement, maintenance, electricity consumption, and so on. The following table illustrates the efficiency and life expectancy of different type of lamps.

| *Lighting technology* | *Efficiency (lumens/W)* | *Life expectancy (hrs)* |
|---|---|---|
| Tungsten filament | 12-15 | 1 000 - 2 000 |
| Standard florescent | 65 | 5 000 - 15 000 |
| Efficient florescent | 90 | 5 000 - 15 000 |
| Low pressure sodium | 110 - 180 | 10 000 - 18 000 |

**TABLE 7** Lighting efficiencies
*Source: De Villiers (1995)*

### *2.5.8 Process improvements*

This is perhaps the most promising area for energy savings. Unfortunately, identification of opportunities involves an intimate understanding of processes, and this is often a barrier to process efficiency upgrades. Opportunities are also specific to industrial sectors. There is currently insufficient information on South African industrial processes to measure the financial implications of process opportunities, but in comparing the energy intensity for the production of similar products from elsewhere, significant improvements are evident.

### 2.6 Cross-sectional issues

A number of energy efficiency tools cross one or more of the sector boundaries, including tariffs. A tariff that affects many sectors, is the time-of-use (TOU) tariff. While this tariff is designed to shift peak demand from times of high to low demand, it is likely to affect fuel switching and encourage a movement towards more efficient electricity transformations which cannot be shifted away from the peak. Although not yet available to residential customers, the TOU pilot tariff, which is applied by Eskom primarily to their industrial and commercial customer base, has achieved considerable peak reductions since initiation in 1986. Berrisford (1995) estimates that between 1987 and 1993 Eskom customers on Tariff E reduced peak demand by 420 MW, despite only 18% of the customers who opted for E tariff having actually changed their electricity consumption behaviour. The cost of these savings is negligible for the supplier, entailing upgrading of the metering technology.

## 3. Energy efficiency interventions in the various sectors

In transport, household, industry and commerce there are areas in which energy efficiency can be improved. This section aims to give an aggregated overview of these improvements and to understand the costs and benefits where they are available of implementing these, but at least to give a sense of the magnitude of the potential and realisable energy savings. The costs and benefits listed are those which apply to the financial flows over the life-cycle of the different energy efficiency options. However, there are impacts on the economy which are wider than those documented below, include environmental and health ones. There could also be benefits which relate to the creation of employment opportunities in retrofitting energy consuming apparatus. The aim of this section is to provide an estimate of size and, where possible, relative costs of the different options in the low-income household sector relative to options in other sectors.

### 3.1 Transport sector

Large gains can apparently be made in the efficiency with which petroleum products are utilised. The costs of some of the interventions which were evaluated are, however, unclear.

| *Types of conservation measures* | *Potential* savings petrol (PJ)* | *Potential* savings diesel (PJ)* | *Cost implications* |
|---|---|---|---|
| Transport demand reduction | 22 | 19 | low cost |
| Transport management | 11 | 9 | some have high capital and subsidy costs |
| Traffic management | 8 | 2 | medium implementation cost, reduce operating costs |
| Road and street planning improvements | 8 | 8 | medium to high implementation cost, reduce operating cost, |
| Vehicle efficiency improvements | 25 | 19 | low to medium cost |
| Driver training | 14 | 14 | low cost |
| Combined measures | 88 | 71 | |

* percentage of the total South African consumption of petrol or automotive diesel for road transport respectively.

**TABLE 8** Transport energy efficiency potential and cost implications
*Source: Dehlen (1986)*

The amounts are large in comparison to the total amount of energy used in the transport sector. From Table 8, a total of 159 Petajoules (PJ), or one-third, of the annual 459 PJ of the liquid fuels which are consumed in this sector could be saved. Unfortunately, there are few indications as to the cost of these reductions and therefore no way to test their practicality. Dehlen (1986) suggests a cautious approach, considering only the least-cost options such as demand reduction, the vehicle and the driver. For this study, these interventions will be considered, resulting in savings of 61 PJ and 52 PJ of petrol and diesel respectively. These interventions are considered as being lower than the cost to the economy of supplying fuels. This implies 133 Pj of energy at a cost lower than the long run marginal cost of supply, that includes the costs of refinery capacity and crude oil.

Another strategy for improving the economic efficiency of liquid fuels supply is suggested by Carvalho (1995) who suggests that considerable end-use efficiency and balance of payments benefits could be gained through encouraging the consumption of a greater proportion of diesel rather than petrol. Currently the ratio between petrol and diesel consumption in South Africa is 2.5:1. Carvalho asserts that direct injection diesel engines are far more energy efficient than petrol engines of a similar capacity. To avoid exporting surplus diesel at a loss to elsewhere in Africa, the use of diesel could be encouraged by making a fiscally neutral incentive of 25c per litre sourced from a 10c per litre levy on petrol. Finally, he insists that transformation to diesel of the mini-bus taxi fleet alone, which uses in the region of 100 million litres of petrol daily, could contribute significantly to alleviating the imbalance, improving energy efficiency and delaying the building of new refineries.

### 3.2 Low-income residential sector

The scenario that is examined below includes the introduction of five demand-side management options. The major components of this programme include:

- the heating of 150 litres of water per household per day from 15 oC to 55oC in a 30:70 (electric:solar) water heater rather than in an electric storage geyser (the SWH has a 2kW, and the electric storage geyser a 3kW, heating element);
- the replacement of two frequently used 20 watt compact fluorescent lightbulb by two 100 watt incandescent lights (with the same light output);
- the thermal performance upgrade of new formal and informal housing so as to reduce peak and total space heating requirements;
- the availability of a time-of-use tariff; and
- an appliance labelling scheme.

These measures are examined in terms of their contribution to energy efficiency and energy conservation as well as their effect on future peak demand for electricity. Where quantitative information was not available,[2] estimates based on figures presented in Eskom's small-customer demand-side management ten-year plan were utilised (Ligoff 1993). In considering low-income households, six million households were included, as the upgrading of these were considered over a 20 year period, with figures based on calculations by Thorne (1995). The estimates also assume an even penetration of the DSM measures over a 20-year period.

2 This was the case with the time-of-use tariff and the appliance labelling components of the demand-side management programme and in assuming the penetration of these.

| *DSM measure* | *Demand savings* | | *Energy savings* | | *Energy savings* |
|---|---|---|---|---|---|
| | *kW* | *R/kW* | *GWh/year* | *R/kWh* | *PJ/year* |
| Thermal performance | 1 736 | 2 354 | 1 586 | 0.09 | 5.8 |
| Lighting | 942 | 706 | 1 080 | 0.03 | 4.0 |
| Time-of-use | 600 | 77 | - | - | - |
| Solar water heating | 2 520 | 1 255 | 1 510 | 0.09 | 5.4 |
| Labelling | 140 | 0 | 1 164 | 0.00 | 4.2 |
| Total | 5 938 | | 5 340 | | 19.4 |

**TABLE 9** Energy savings in low-income urban and rural households

### 3.3 Medium-to-high-income residential sector

For medium-to-high-income households, a figure of two to three million existing households is also considered as reasonable. Amongst these households the potential for energy savings is technically far higher than for low-income houses precisely because so much energy is utilised, and the use of electricity is at a saturation level. While this implies a possible lower rate of penetration of energy efficient technologies, it also implies a higher initial cost which could be attributable to retrofitting equipment which may not have come to the end of its useful life. Retrofitting could also result more than one appliance being used in the household - for example two refrigerators. The converse could apply in the case of light-bulbs, which have comparatively short lives. Though a fluorescent light will have a higher first cost than an incandescent light, it is less likely to be a barrier for the medium-to high-income households than it may for the low-income residential sector.

### 3.4 Industrial sector

The following table gives a rough indication of energy savings potential. Although electricity saving potential may appear to be small compared with total energy savings, when converted to energy costs electricity savings will become more significant.

| *Measure* | *Annual energy saving potential* | *Electricity saving potential* | | *Energy saving potential as a percentage of total energy consumption* |
|---|---|---|---|---|
| | *Petajoules* | *GWh/year* | *MW* | |
| Efficient motors | 2 | 550 | 60 | 0.2 |
| Variable speed drives | 4 | 1 100 | 120 | 0.4 |
| Cogeneration | 23 | - | - | 2.3 |
| Housekeeping | 48 | 1 900 | 220 | 5.0 |
| Boilers | 10 | - | - | 1.0 |
| Insulation | 5 | - | - | 0.5 |
| Lighting | 5 | 1 400 | 160 | 0.5 |
| Process improvements | unknown | unknown | unknown | unknown |
| Total | 97 | 5 000 | 560 | |

**TABLE 10** Industrial energy saving potentials

### 3.5 Commercial sector

The main possibilities for energy savings in this sector are in improved air-conditioners and light technologies, where it has been estimated that 25% and 13% could be saved respectively. It is estimated that in municipalities approximately 16 000 GWh were consumed in the commercial sector in 1993. Of this, 44% and 25% were used for air-conditioning and lighting respectively. This implies 1 800 GWh (6.5 Petajoules) and 520 GWh (1.8 Petajoules) electricity savings per year at costs below that of supply (in the text from which this information was sourced Rosseau (1995) examines only DSM measures with payback periods shorter than two years.) There would be little contribution to peak reduction emerging from commercial buildings as there is unlikely to be coincidence of commercial energy use and times of national peak demands (which occur on the evenings of the coldest nights of the year.)

### 3.6 Conservation supply curve

A crude undisaggregated conservation supply curve for the different sectors using some examples of each would contain little information other than potential savings. It would not include (with the exception of the low income sector), costs for the various energy efficiency strategies. However, it would show which savings are below the level of the cost of supply.

Figure 2 gives an indication of the energy efficiency strategies which are lower than the cost of supplying the energy service, or "no regrets" options. The strategies are applied in order to improve the efficiency of energy used in four energy consuming sectors in the South African economy. The figures on which Figure 2a, b, c, d and e is based, are included in Appendix B.

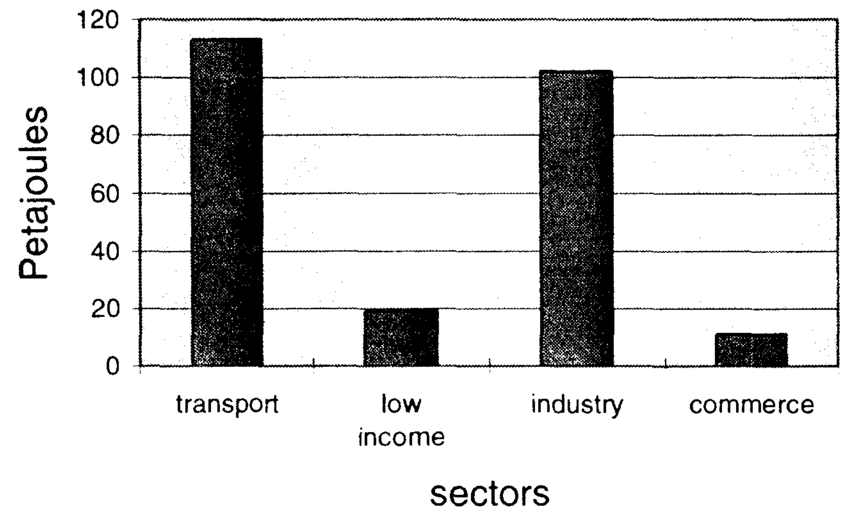


**FIGURE 2a** The extent of 'no-regrets' energy efficiency options in the different sectors

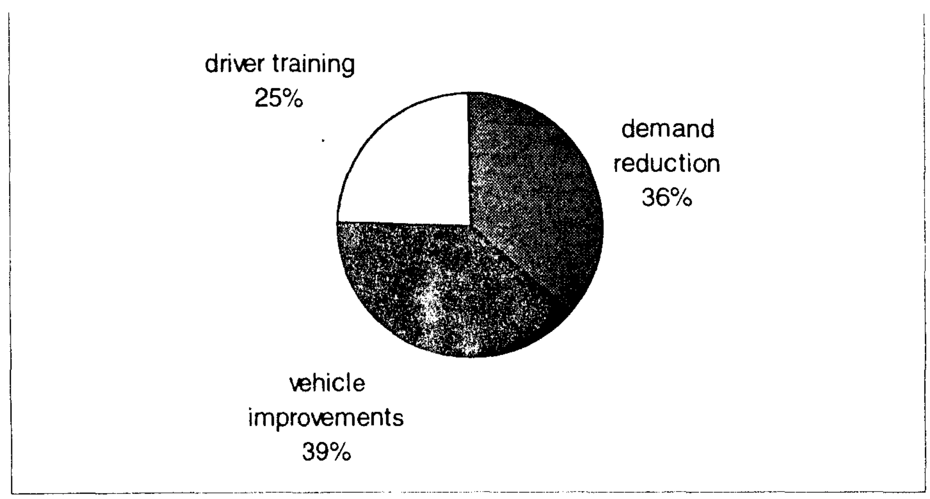


**FIGURE 2b** Options in the transport sector

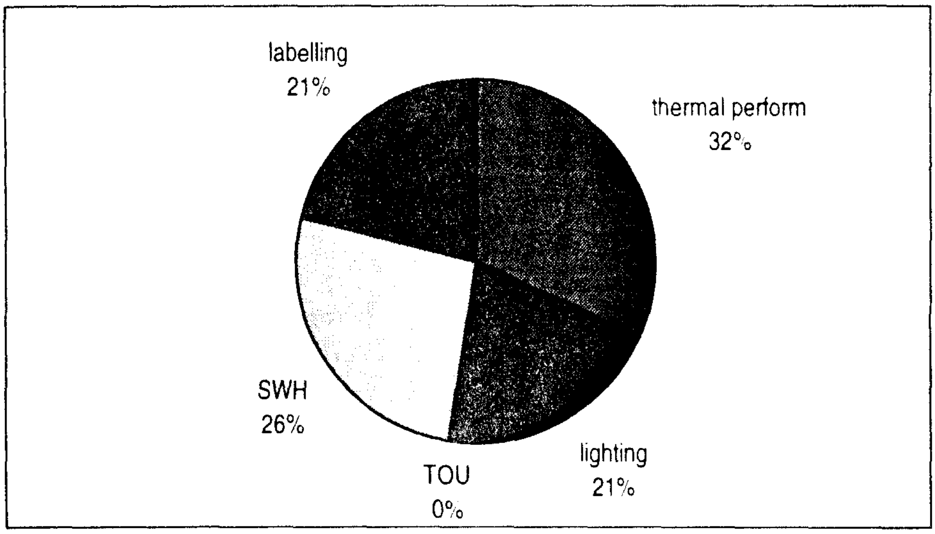


**FIGURE 2c** Options in the low-income household sector

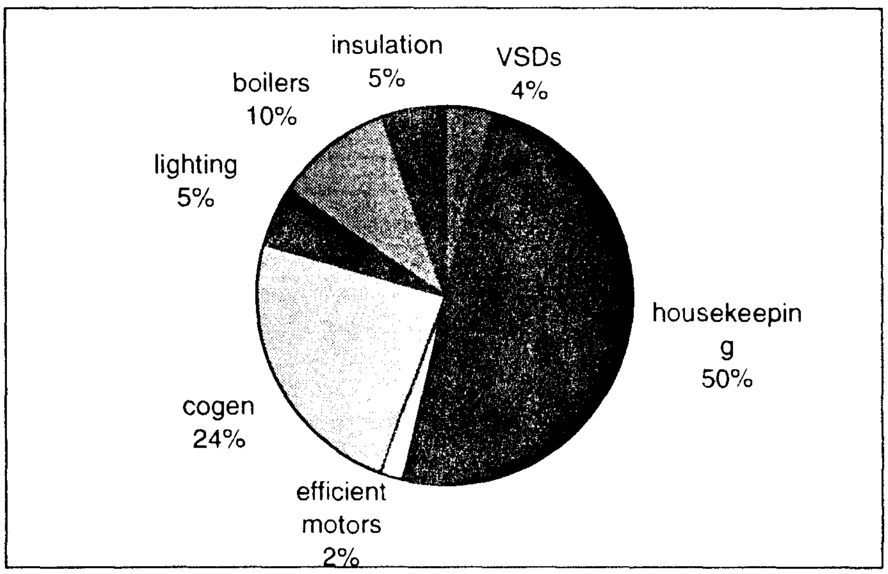


**FIGURE 2d** Options in the industrial sector

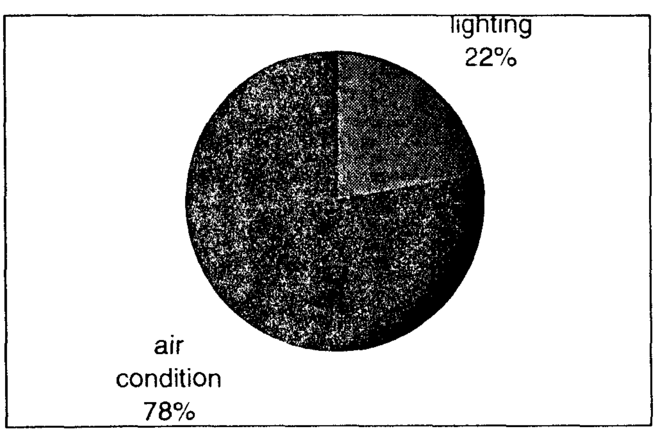


**FIGURE 2e** Options in the commercial sector

# 4. Conclusions

Consecutive *Enerconomy* conferences have estimated that the energy savings acchievable by South African industry and commerce lies between 10% and 30% (Dutkiewicz 1992). This short paper has totalled an amount of 238 PJ, and an electricity demand saving of 6 860 MW. This is equivalent to 12% of final consumption of energy in South Africa in 1990 and 19% of the total installed electricity generating capacity.

The information presented in this document is sourced from a variety of papers, conference proceedings discussions and written correspondence. Some of the sources refer to potential energy savings in new facilities (Thorne 1995), others to retrofits of existing facilities (de Villiers 1995), while still others give figures of savings to date (Berrisford 199?). However, very few give indications of the cost, other than to say that the savings are achieved at a cost below that of supply. The strategies selected could therefore be considered, (with the possible exception of those applied to transport) to be, in climate change jargon 'no regrets' options.

The conclusion that can be drawn from the limited local information available on energy demand management is that there are opportunities to improve the energy performance of the South African economy. Yet little is known about the size or the costs of capturing these efficiency gains.

It is hoped that this short document can be considered as a first attempt to understand and quantify energy efficiency opportunities. Future estimates could provide more details of identified programmes and extend the range of opportunities. Until there has been further work, there is too little information on which to base a comparative costs and benefit assertion that low-income households are a higher priority on economic grounds for energy efficiency improvements than, say, demand management opportunities in industrial facilities, or vise versa.

What is clear, however, is that energy efficiency literature does suggest that improvements at the time of access to energy services make more sense than retrofitting to improve efficiency. Low-income housing is being built and simultaneously electrified. The majority of citizens are gaining access to electricity for the first time. With a development policy driving the creation of jobs and arguing for basic needs to be met, the contributions that energy efficiency could bring to improve the affordability of energy services and the mitigation of health problems associated with warmer and cleaner micro-environments, should be compelling. Seed support for improvements reducing greenhouse gas emissions could come from international agencies such as the Global Environment Facility (GEF). The GEF is prepared to cover the incremental cost (over the life-cycle) of pilot technologies that provide global environmental benefits.

It is apparent that the preparation of conservation supply curves for the South African economy will have to be prepared soon, once more information is available. When this is next attempted, costs to the national (and global) economy normally considered as externalities should be included.

# Appendix A: Efficiency of producing and using energy in industrial, commercial (and domestic) sectors

| *Application* | *% Industry and commerce* | *Energy carrier* | *Primary conversion* | *Transport losses* | *Final conversion efficiency* | *Total conversion efficiency* |
|---|---|---|---|---|---|---|
| Thermal | 12 | electricity | 33 | 8 | 90 | 27 |
| | 38 | coal | n/a | 5 | 60 | 57 |
| | 3 | petroleum | 90 | 2 | 70 | 62 |
| | 12 | coal gas | 70 | 3 | 75 | 51 |
| | n/a | natural gas | n/a | 3 | 80 | 78 |
| | 3 | biomass | n/a | 5 | 70 | 67 |
| Mechanical | 13 | electricity | 33 | 8 | 85 | 26 |
| Lighting | 3 | electricity | 33 | 8 | 5-20 | 2-6 |
| Chemical (1) | 3 | electricity | 33 | 8 | n/a | n/a |
| | 12 | coke | 50 | 5 | n/a | n/a |
| Transport | 0 | electricity | 33 | 8 | 50-60 | 15-18 |
| | 1 | petroleum | 90 | 2 | 15-30 | 13-26 (2) |
| Cooking (3) | 0 | wood | 115 | - | 13 | 15 |
| | 0 | paraffin | 90 | (2) | 30 | 26 |
| | 0 | electricity | 33 | (8) | 60 | 18 |

*Notes:*

1. electrolysis
2. petrol and diesel respectively
3. this material is sourced from Leach and Gowen (1987)

**TABLE A1** Efficiency of producing and using energy in industrial, commercial (and domestic) sectors
*Source: Neethling and Dutkiewicz (1993)*

# Appendix B:
# Summary table of energy savings potential in the different sectors

| *Sector* | *Strategy* | *Fuel/s* | *Consumption savings (PJ)* | *Cost of consumption savings (Rands/PJ)* | *Demand saving (kW)* | *Costs of saved demand (R/kW)* |
|---|---|---|---|---|---|---|
| Transport | demand reduction | petrol and diesel | 41 | - # | - | - |
| | vehicle improvements | petrol and diesel | 44 | - # | - | - |
| | driver management | petrol and diesel | 28 | - # | - | - |
| Low-income residential | thermal performance | electricity/coal/wood/ | 6 | R25 mil | 1700 | 0.09 |
| | lighting | electricity | 4 | R8 mil | 940 | 0.03 |
| | TOU | electricity | 0 | - | 600 | - |
| | SWH | electricity | 5 | R25 mil | 2 500 | 0.09 |
| | labeling | electricity | 4 | 0 | 140 | 0 |
| High- to mid-income | | | | | | |
| Industry | efficient motors | electricity | 2 | - # | 60 | - # |
| | variable speed drives | electricity | 4 | - # | 120 | - # |
| | cogeneration | heat | 23 | - # | - | - |
| | housekeeping | all fuels | 48 | - # | 220 | - # |
| | boiler | all fuels | 10 | - # | - | - |
| | insulation | all fuels | 5 | - # | - | - |
| | lighting | electricity | 5 | - # | 160 | - # |
| | process improvements | all fuels | ? | - # | ? | - |
| | time-of-use tariffs | electricity | - | 0 | 420 | 0 |
| Commerce | air-conditioning | electricity | 7 | - # | 0 | - |
| | lighting | electricity | 2 | - # | 0 | - |
| Total | | | 238 | | 6 860 | |

Note: # = cost not calculated but below the cost of supply.

**TABLE B1** Summary table of energy savings potential in the different sectors

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